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Reopeation rate after microsurgical uni- or bilateral laminotomy for lumbar spinal stenosis with and without low-grade spondylolisthesis: What do preoperative radiographic parameters tell us?

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Abstract

Study Design: Retrospective single-center cohort study.

Objective: The aim of this study was to analyze the influence of preoperative radiographic parameters on reoperation rates after microsurgical laminotomy for lumbar spinal stenosis (LSS).

Summary of Background Data: Decompression for symptomatic LSS has shown to be effective. However, the optimal surgical strategy remains a matter of debate, especially with underlying spondylolisthesis.

Methods: Adult patients with LSS who underwent primary laminotomy without fusion between January 2012 and September 2013 at our institution were included for analysis. Disc height (in mm), facet joint orientation (degrees) and grade of spondylolisthesis of all surgical index levels (SILs) were analyzed from preoperative magnetic resonance imaging. Patients were contacted in January 2017 by follow-up phone call (mean follow-up 49 months) regarding lumbar reoperation.

Results: A total of 161 patients (mean age 68.5 years, ± 11.3) and 236 SILs were analyzed. Fifty-six patients (34.8%) had low-grade spondylolisthesis involving 60 SILs (25.4%). Twenty-four patients (14.9%) underwent reoperation involving 32 levels. Of latter, 23 SILs (9.7%) had recurrent stenosis and 9 (3.8%) had adjacent level stenosis. Five patients in total (3.1%) required secondary fusion; all had preexisting spondylolisthesis. SILs with spondylolisthesis had a significantly higher rate of recurrent stenosis requiring reoperation compared to SILs without spondylolisthesis (18.3% (11/60) vs. 6.8% (12/176), $p = 0.013$). Disc height and facet joint orientation showed no significant difference between patients with and without reoperation, or with and without spondylolisthesis.

Conclusions: Decompression alone is reasonable for most patients with LSS and stable low-grade spondylolisthesis. The overall reoperation rate and need for secondary fusion were low in our series. However, patients with spondylolisthesis had a higher rate of reoperation for recurrent stenosis after laminotomy without fusion. This must be taken into account for preoperative risk-benefit analysis, tailored surgical decision-making and patient counseling.

Key Words: Decompression; degenerative disease; degenerative spondylolisthesis; disc degeneration; laminectomy; laminotomy; lumbar spinal stenosis; lumbar spine; reoperation; spinal fusion

Level of evidence: 4

Introduction

Lumbar spinal stenosis (LSS) with or without concomitant low-grade degenerative lumbar spondylolisthesis is quite common in the elderly population and the cause of chronic low back pain and radiculopathy. The prevalence of absolute LSS in the population aged 60 to 69 years is estimated to be 20%.[1] Surgical decompression for LSS has repeatedly been shown to be effective and superior to conservative treatment in selected patients.[2-4] Traditionally, wide laminectomy used to be the gold standard for symptomatic LSS refractory to non-surgical treatment. However, with open conventional laminectomy good or excellent outcomes were seen in merely 64% according to a metaanalysis.[5] Surgical failure has been attributed in part to postoperative spinal instability due to disruption of the posterior supporting structures. To overcome this concern, less invasive decompression procedures have been described such as unilateral or bilateral laminotomies and lumbar spinous process-splitting laminectomy with comparable or superior outcomes to standard laminectomy, respectively.[6-8] Whether or not to supplement decompression with fusion for LSS with underlying low-grade spondylolisthesis remains a matter of debate despite recent publication of two randomized controlled trials in the *New England Journal of Medicine*.[9,10]

The rates for reoperation after decompression without fusion for LSS are rather consistently reported to be around 8-10% 2 to 4 years following surgery.[2,11] When considering the need for supplementing lumbar decompression with instrumented fusion, a more tailored approach taking specific preoperative radiographic risk factors into account may help to further reduce reoperation rates.

For degenerative lumbar spondylolisthesis it has been shown that the respective facet joints are more orientated towards the sagittal plane, thus supposedly predisposing that lumbar level to slip out of alignment.[12-14] Moreover, motion at the spondylolisthesis level, disc height, and facet joint angle are thought to be radiographic predictors for secondary instability and reoperation following decompression without fusion for low-grade spondylolisthesis.[15] While such radiographic parameters have been analyzed in degenerative spondylolisthesis in regards to postoperative instability, no study to date has systematically examined the influence of facet joint orientation and disc height on reoperation rates for LSS.

The objective of the present study was to analyze potential radiographic predictors for reoperation in patients who underwent microsurgical uni- or bilateral laminotomy for LSS. We also sought to analyze the cause for reoperation, i.e. whether it was performed for recurrent stenosis or for secondary instability requiring instrumented fusion.

Materials and Methods

Study design

This was a retrospective single center cohort study. Both the local ethics committee (Kantonale Ethikkommission Bern Ref.-Nr. 2016-01599) and the institutional review board of our University Hospital approved the data collection. The study was conducted according to GCP guidelines and the Declaration of Helsinki. A written general consent was obtained from all patients included into the study.

Patient population and eligibility

All adult patients (aged 18 years and older) who underwent primary lumbar decompression by means of unilateral laminotomy with unilateral or bilateral over-the-top decompression or bilateral laminotomy without fusion for symptomatic degenerative LSS between January 2012 and September 2013 at our institution were screened for eligibility. Patients with recurrent stenosis who already had a previous lumbar decompression at the surgical index level(s) (SIL) and patients with preexisting instrumented lumbar spinal fusion were excluded from the study.

Surgical technique

In the present study LSS was decompressed in a standardized fashion, using a less invasive facet joint sparing microsurgical technique by uni- or bilateral laminotomies through a midline incision sparing the posterior midline structures. For patients with underlying spondylolisthesis hypermobility as a sign of segmental instability (slip of ≥ 3 mm or relevant increase of spondylolisthesis from lying to upright standing position) was ruled out by upright flexion-extension lumbar radiographs. Decompression with instrumented fusion for LSS was generally reserved for patients with spondylolisthesis deemed as unstable by the surgeon and a main complaint of predominant mechanical low back pain refractory to conservative treatment.

Radiographic parameters and data acquisition

For all included patients every decompressed SIL was analyzed separately for the following radiographic parameters as depicted in the preoperative magnetic resonance imaging (MRI) of the lumbar spine: disc height (in mm), facet joint (FJ) angle (degrees), and Meyerding grade (0-4) of spondylolisthesis (Figure 1). The FJ angle was calculated relative to the sagittal plane through the center of the vertebral body and spinous process. Low-grade lumbar spondylolisthesis was defined as a Meyerding grade of 1 or 2, corresponding to an anterior translation of up to 25% or 50%, respectively.[16]

Patients were contacted by follow-up phone call in January 2017. Patients were questioned on whether they had undergone any second or revision surgery of their lumbar spine in the meantime at our institution or at any other hospital. Operative notes for any reoperations were obtained from our electronic patient records, or from the family physician for reoperations performed at outside hospitals. The primary study endpoint was the rate of reoperations at the

SIL for recurrent LSS or secondary instability. Secondary endpoints were rate of decompression of new lumbar levels for adjacent level stenosis.

Statistical analysis

Data are given as mean values ± standard deviation. Odds ratios with associated 95% confidence intervals and p-values were calculated from logistic regression models. To account for clustering of observations on SILs within patients, we used robust standard errors. A *P* value of less than 0.05 was considered statistically significant. Statistical analysis was performed using Stata (StataCorp. 2017. Stata Statistical Software: Release 15. College Station, TX: StataCorp LLC).

Results

The mean follow-up was 49 months (range 39-60 months). Out of a total of 179 eligible patients 161 patients (95 men, 66 women, mean age 68.5 years ± 11.3) were approachable by follow-up phone call and were included for final analysis. In total 236 stenotic lumbar levels were decompressed. Preexisting spondylolisthesis was present in 60 SILs (25.4%) in 56 patients (34.8%) and all had low-grade spondylolisthesis (Meyerding grade I in 56 SILs, grade II in 4 SILs) (Table 1).

Twenty-four patients (14.9%) had a first reoperation involving 32 lumbar levels (including SILs and new levels). Of latter, 23 SILs (9.7%) in 17 patients (10.6%) had recurrent stenosis, and 9 new levels (3.8%) were decompressed for adjacent level stenosis in 8 patients (5.0%). One patient with reoperation had both recurrent stenosis of a SIL and adjacent level stenosis. Five patients out of the cumulative reoperation group were revised with decompression and instrumented fusion, corresponding to an overall secondary fusion rate of 3.1% (5/161). Four of these patients had recurrent stenosis at the SIL with preexisting low-grade spondylolisthesis (Meyerding grade I in 3 L4-5 levels, grade II in 1 L5-S1 level). Only one patient required a third operation (second reoperation) for recurrent stenosis and adjacent level stenosis and was treated with decompression and fusion. Table 2 gives detailed information on all reoperations of SILs.

SILs with preexisting spondylolisthesis had a significantly higher rate of recurrent stenosis requiring reoperation compared to SILs without spondylolisthesis (18.3% (11/60) vs. 6.8% (12/176), odds ratio 3.068, 95%CI 1.268-7.424; p=0.013) (Figure 2). The secondary fusion rate was significantly higher for SILs with spondylolisthesis than for SILs without spondylolisthesis (6.7% (4/60) vs. 0.6% (1/176), odds ratio 12.5, 95%-CI 1.3-122.3, p=0.03). Disc height and FJ angles of SILs showed no statistically significant association with need of reoperation or secondary fusion. Table 3 gives a comprehensive overview of all analyzed radiographic parameters per SIL dichotomized into groups with and without reoperation.

Discussion

Reoperation rates after lumbar decompression

In our series the overall rate of first reoperation 39 to 60 months after microsurgical laminotomy for LSS was 15%. For a single SIL the reoperation rate of symptomatic recurrent stenosis was 9.7%, corresponding to 10.6% of all included patients. These figures are consistent with previously reported reoperation rates following lumbar decompression in the spine literature. In the SPORT trial on lumbar stenosis the reoperation rate at 2 years was 8%, and 18% at the 8-year follow-up.[2,17] The 4-year reoperation rate of Medicare patients operated on in 1985 was found to be 10.2% for patients who had decompression alone.[18] The 11-year cumulative incidence of reoperation in a retrospective study of nearly 25,000 patients who underwent lumbar surgery for degenerative spine disorders was 19%, and 16.8% for patients with spinal stenosis after decompression alone.[19] Recently, in the Swedish Spinal Stenosis Study on lumbar stenosis with and without low-grade spondylolisthesis, Försth and colleagues reported a reoperation rate of 15% in the fusion group and 11% for the decompression-alone group within 2 years.[9] In the study by Ghogawala et al. published at the same time patients with low-grade spondylolisthesis in the decompression-alone group had a relatively high reoperation rate of 34% after 4 years following conventional laminectomy with partial removal of the medial facet joints.[10]

Risk factors for reoperation following decompression

Recognizing and understanding possible risk factors for poor outcome and reoperation after surgery for LSS is critical for selecting the most optimal surgical technique offered to these patients and patient counseling. A multitude of potential risk factors that may predispose patients to require a reoperation following decompression for LSS have been investigated. Specific patient characteristics such as diabetes, gender, obesity, smoking, and comorbidities, or severity of stenosis and number of decompressed levels have been shown not to be associated with higher reoperation rates.[10,17,20,21] However, one study found patients covered by workers' compensation to be at a substantially higher risk of reoperation.[11] Since the mean age of patients in our study was above retirement age that would not have had a significant impact on our results. To date anatomical or radiographic parameters have been analyzed mainly to determine the risk of secondary instability following decompression in degenerative spondylolisthesis. Motion at spondylolisthesis level, disc height and facet joint angles have previously been analyzed and found to be radiographic predictors of delayed instability and reoperation following decompression in low-grade spondylolisthesis in a study by Blumenthal et al.[15] However, in this study all included patients were treated by standard open laminectomy, which might have further promoted disease progression and secondary instability, ultimately contributing to their high reoperation rate of 37.5%. Another study found that patients with more sagittally oriented facet joints and preserved disc heights were more likely to require secondary fusion after a midline sparing decompression for degenerative spondylolisthesis.[22] The present study is the first to systematically evaluate the influence of FJ orientation and disc height on reoperation rates after laminotomy for LSS with and without spondylolisthesis. While these parameters may play a role for segmental stability in spondylolisthesis, we found no association of disc height or FJ angles with higher reoperation rates in our series. This is in line with results from the Spine Patient Outcomes Research Trial for degenerative spondylolisthesis, in which disc height generally had no association with outcomes in either the surgically or nonoperatively treated patients.[23] However, underlying low-grade spondylolisthesis at the SIL was the single most important risk factor for same level reoperation for symptomatic recurrent stenosis in our study for patients operated on by microsurgical uni- or bilateral laminotomies.

Influence of the surgical technique on reoperation

The surgical technique for decompression of lumbar stenosis has been shown to play a key role for good outcome, but the optimal technique still remains a matter of debate. Conventional open facet-sparing laminectomy with inevitable disruption of the posterior tension band still is the standard procedure for treatment for LSS in many institutions. However, less invasive techniques such as uni- or bilateral laminotomies have been developed to better preserve spinal integrity and avoid removal of posterior midline structures. In the past, unilateral or bilateral laminotomy has been shown to be advantageous over open laminectomy in terms of success rate, complications and patient satisfaction.[6,24] Yet, a Cochrane systematic review published in 2015 comparing the effectiveness of different techniques of posterior decompression that limit the extent of bony decompression or avoid removal of posterior midline structures of the lumbar spine vs. conventional laminectomy found the evidence to support this hypothesis to be of low or very low quality.[25] Still, a more recent meta-analysis comparing open laminectomy vs. unilateral laminotomy in LSS with stable low-grade spondylolisthesis found latter technique to be associated with lower reoperation (16.3% vs. 5.8%) and secondary fusion rates (12.8% vs. 3.3%), as well as less progression of underlying spondylolisthesis.[26]

The implication of degenerative spondylolisthesis

Some authors support the theory that an inherent instability and the actual slippage in spondylolisthesis might be the origin of lumbar stenosis in many patients.[27] Thus, decompression alone would not address the true culprit, the inherent instability, but rather would further destabilize the spinal segment. However, there is still no consensus on the definition of the term instability. Our findings might stir up the ongoing debate on whether a primary fusion is necessary for LSS with concomitant spondylolisthesis. Even after two recently published randomized controlled trials in the *New England Journal of Medicine*, data show somewhat conflicting results and the question remains unanswered.[9,10] In our study the risk for a SIL requiring a reoperation for recurrent stenosis at a mean follow-up of 4 years following decompression alone for LSS with underlying low-grade spondylolisthesis was 18%, which was nearly threefold higher than for LSS without spondylolisthesis (6.8%). A primary fusion might not only prevent secondary instability but also the development of secondary stenosis. However, with an overall reoperation rate with fusion of 3.1% within 39 to 60 months, which is well in accordance with the current literature,[26] we cannot conclude that a fusion should thus be offered to every patient with low-grade spondylolisthesis. The higher reoperation rate in our series for decompression alone of LSS with spondylolisthesis must be weighed against higher complication and reoperation rates for lumbar fusion. Essentially, 10% of patients will require additional surgery for adjacent segment disease within 10 years after lumbar fusion, with patients older than 60 years of age having a significantly higher risk for revision surgery.[28] Our results and conclusion are in line with the effort to avoid the higher perioperative risks of an instrumented fusion in the generally elderly patient population, who are often burdened by comorbidities, and risk factors for hardware failure such as smoking and osteoporosis, and lastly, it is in line with most patients' expectations.

Limitations

Our study has limitations. First, this is a retrospective analysis and there is no reporting on patient-rated outcome to further evaluate the success or failure of the initial surgery. Second, reoperation rates do not necessarily represent a success or failure rate of surgery since some patients might simply be reluctant and refuse to undergo a reoperation deemed necessary following a first failed back surgery. Third, since this is a single institution study, our results are not necessarily generalizable or representative of the population with LSS at large. Finally, the relatively small sample size of our study may limit the ability to demonstrate a clear influence of the measured radiographic parameters with regard to reoperation rates.

Conclusion

FJ orientation and disc height had no impact on reoperation rates following primary laminotomy for LSS. Underlying low-grade degenerative lumbar spondylolisthesis in LSS put patients at a nearly threefold higher risk for requiring a reoperation for recurrent stenosis after microsurgical laminotomy without fusion. However, the need for secondary instrumented fusion was merely 3.1%. Decompression alone by means of a limited and midline tension band respecting laminotomy seems reasonable for most patients suffering from LSS, even with stable spondylolisthesis. Patients need to be informed about their individual risk for requiring a reoperation following the index surgery.

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Figure legends

Figure 1 Measurement of radiographic parameters on a preoperative T2 weighted MRI: Degree of spondylolisthesis was assessed using the Meyerding classification (A). The distance between the superior and inferior endplates at the midpoint of the spondylolisthesis where applicable, was measured for determining the disc height (B). The facet joint angles were calculated relative to the midsagittal plane on an axial image (C).

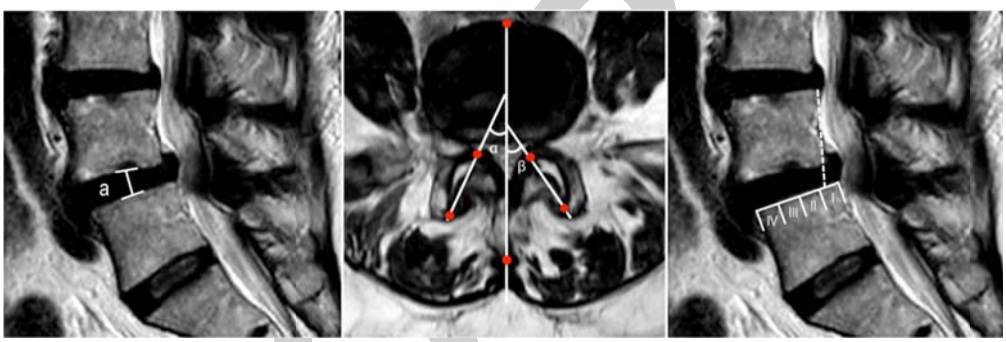

Figure 2 Association of surgical index levels (SILs) with and without underlying spondylolisthesis and rate of reoperation for recurrent stenosis.

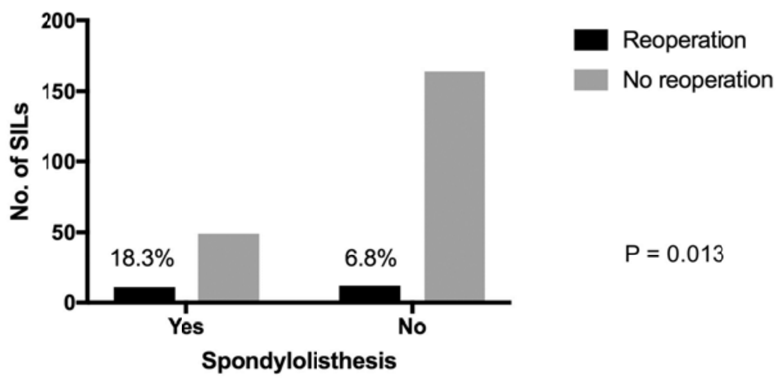

Table 1 Overview of surgical index levels and radiographic parameters

Stenosis levels	No. of SILs (n = 236)	SIL with spondylolisthesis (no., %)	Disc height (mean in mm)	Facet joint orientation (mean in degrees)	
				Left	Right
L1-L2	2	0	5.8±1.2	47.0±8.5	33.5±4.9
L2-L3	33	6 (18.2)	7.8±2.5	35.3±7.6	32.6±8.7
L3-L4	79	12 (15.2)	8.3±2.4	39.2±9.7	36.5±8.8
L4-L5	111	38 (34.2)	8.7±2.4	46.6±11.0	42.0±11.6
L5-S1	11	4 (36.4)	6.9±3.2	54.1±21.1	42.6±10.5

SIL surgical index level

Table 2 Overview of all reoperations, and type of surgery.

No.	Age - yr	Sex	SIL of primary decompression	First reoperation and indication	Second reoperation and indication
1	68	F	L3-4	L4-5 D for ALS	-
2	43	F	L4-5	L4-5 D for RS	-
3	83	M	L5-S1†	L5-S1 D for RS	-
4	47	M	L5-S1‡	L5-S1 D+F for RS	-
5	67	M	L4-5	L3-4, L4-5 D for ALS and RS	-
6	71	M	L2-3, L3-4	L3-4 D for RS	-
7	64	F	L2-3, L3-4, L4-5†	L2-3, L3-4, L4-5 D for RS	-
8	69	M	L3-4, L4-5	L4-5 D for RS	-
9	65	F	L2-3, L3-4†	L4-5 D for ALS	-
10	78	M	L2-3†, L3-4†, L4-5	L2-3, L3-4, L4-5 D for RS	L4-5, L5-S1 D+F for RS, ALS
11	78	F	L2-3‡, L3-4‡	L2-3, L3-4 D for RS	-
12	57	M	L4-5	L3-4 D for ALS	-
13	62	M	L4-5	L3-4 D for ALS	-
14	72	M	L2-3, L3-4, L4-5, L5-S1†	L2-3, L4-5 D for RS	-
15	83	M	L3-4, L4-5	L3-4 D for RS	-
16	63	M	L4-5	L4-5 D for RS	-
17	62	M	L4-5	L3-4 D for ALS	-
18	77	F	L5-S1†	L5-S1 D for RS	-
19	44	F	L4-5†	L4-5 D+F for RS	-
20	61	M	L2-3, L3-4	L4-5, L5-S1 D for ALS	-
21	65	M	L3-4	L3-4 D for RS	-
22	77	F	L4-5†	L5-S1 D for ALS	-
23	49	F	L4-5†	L4-5 D+F for RS	-
24	81	M	L4-5†	L4-5 D+F for RS	-

ALS adjacent level stenosis, D decompression, F fusion, SIL surgical index level, † spondylolisthesis Meyerding grade I, ‡ spondylolisthesis Meyerding grade II, RS recurrent stenosis.

Table 3 Association of disc height and facet joint orientation of surgical index levels (SILs) with recurrent stenosis requirirng reoperation and secondary fusion.

	No reoperation	**Reoperation**				
No of patients	**n=144**	**n=17**				
No of SILs	**n=213**	**n=23**	**Odds Ratio**	**P Value**	**Multivariable OR***	**P Value**
Disc height (mean in mm)						
L1-L2	n = 2, 5.2 ± 0.2	n = 0	NA	NA		
L2-L3	n = 29, 8.0 ± 2.6	n = 4, 6.9 ± 1.6	0.82	0.282	0.83	0.356
L3-L4	n = 73, 8.4 ± 2.4	n = 6, 8.2 ± 2.4	0.97	0.857	0.98	0.897
L4-L5	n = 101, 8.8 ± 2.4	n = 10, 7.9 ± 2.1	0.86	0.202	0.85	0.212
L5-S1	n = 8, 7.3 ± 3.2	n = 3, 5.8 ± 3.7	0.84	0.485	0.67	0.151
SILs with spondylolisthesis	n = 49, 7.8 ± 2.4	n = 11, 6.9 ± 2.5	0.86	0.311	0.86	0.306
Facet joint angle ** (mean in °)						
L1-L2	n = 2, 40.2 ± 6.7	n = 0	NA	NA		
L2-L3	n = 29, 33.7 ± 7.5	n = 4, 35.5 ± 4.5	1.03	0.474	1.02	0.682
L3-L4	n = 73, 37.7 ± 8.5	n = 6, 39 ± 5.8	1.02	0.595	1.02	0.591
L4-L5	n = 101, 44.4 ± 10.4	n = 10, 43.2 ± 9.4	0.99	0.674	0.99	0.675
L5-S1	n = 8, 51.2 ± 15.2	n = 3, 40.7 ± 4.6	0.92	0.162	0.84	0.043
SILs with spondylolisthesis	n = 49, 41.2 ± 10.9	n = 11, 40.7 ± 3.3	0.99	0.767	0.99	0.661
	No secondary fusion	**Secondary fusion**				
Disc height (mean in mm)	n = 231, 8.4 ± 2.4	n = 5, 7.3 ± 3.0	0.84	0.403	0.84	0.394
Facet joint angle (mean in °)	n = 231, 40.9 ± 10.4	n = 5, 40.3 ± 3.1	0.99	0.696	0.99	0.452

SIL surgical index level

* OR adjusted for facet joint for disc height and vice-versa.

** averaged between left and right for each patient in each level.